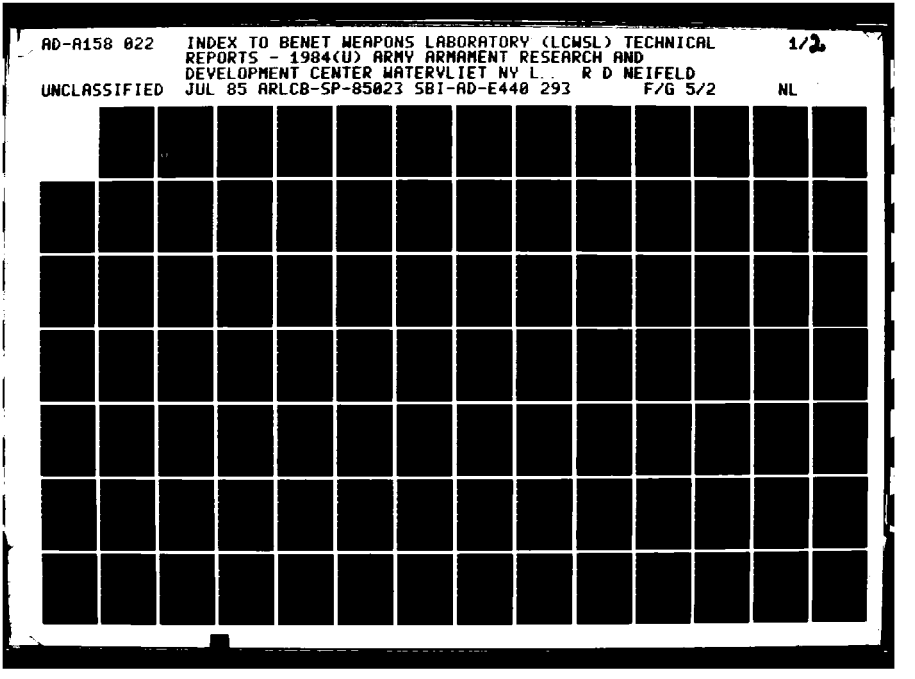
AD-A158 022 INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1984(U) ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER WATERVLIET NY L... R D NEIFELD
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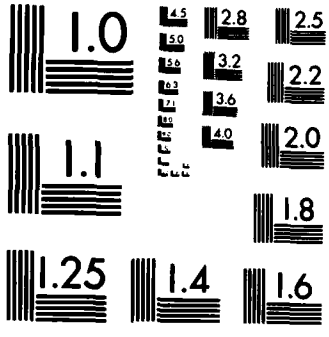

MICROCOPY RESOLUTION TEST CHART
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SPECIAL PUBLICATION ARLCB-SP-85023

INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS — 1984

R. D. NEIFELD

TECHNICAL PUBLICATIONS AND EDITING UNIT

JULY 1985

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT CENTER
LARGE CALIBER WEAPON SYSTEMS LABORATORY
BENÉT WEAPONS LABORATORY
WATERVLIET N.Y. 12189

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11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801-5001		12. REPORT DATE July 1985 13. NUMBER OF PAGES 105
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Benet Weapons Laboratory
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This is a compilation of Benet Weapons Laboratory technical reports published during 1984.

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ARLCB-TR-84002	A Method of Analyzing Perforated Muzzle Brake Performance	CPT R.E. Dillon, Jr. H.T. Nagamatsu	Feb 84
ARLCB-TR-84003	Evaluation of Manganese Phosphate Coatings	R.A. Farrara	Feb 84
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ARLCB-TR-84033	Autonomous Navigation for Mobile Robot Vehicles Over Hilly Terrain Using Rangefinding Measurements	C.N. Shen	Oct 84
ARLCB-CR-84034	Stress Corrosion Cracking Behavior of Tungsten Heavy Alloys	J.-G. Chung D.J. Duquette J.A. Kapp (BWL POC)	Oct 84
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ARLCB-TR-84038	Studies of Hydrostatic Coextrusion of Depleted Uranium-0.75 Titanium Alloy Reinforced with Tungsten Filament (A Progress Report)	I. Ahmad R.J. Fiorentino E.G. Smith, Jr. J. Barranco	Nov 84
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ARLCB-TR-84042	The Development of a Large Composite Anode for Plating Gun Tubes	G. D'Andrea R. Murray	Dec 84

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FMC Corporation Minneapolis, MN	ARLCB-CR-84011
Rensselaer Polytechnic Institute Troy, NY	ARLCB-CR-84034

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1. REPORT NUMBER ARLCB-TR-84001	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) STRESS DISTRIBUTION IN A CYLINDRICAL BAR SUBJECTED TO CYCLIC TORSIONAL LOADING		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. C. T. Chen H. C. Wu (University of Iowa)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A325B541A1A
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18. SUPPLEMENTARY NOTES

Presented at First Army Conference on Applied Mathematics and Computing, George Washington University, Washington, D.C., 9-11 May 1983.
Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Torsion	Endochronic Theory
Cyclic Loading	Stress Distribution
Cylindrical Bar	Plasticity

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The modified version of the endochronic theory of plasticity is applied to the problem of a cylindrical bar subjected to cyclic fully-reversed torsional loading. The governing equations of integral form are derived for pure shear deformation. Analytical techniques are employed in the solution of these equations. A material with appreciable cyclic hardening behavior is studied. The shear stress-strain curve of such a material under a strain-controlled
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20. ABSTRACT (CONT'D)

condition is presented for all cycles until a steady loop is reached. The stress distributions in a cylindrical bar at different stages of loading and unloading are calculated. Some numerical results are presented.

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-84002	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): A METHOD OF ANALYZING PERFORATED MUZZLE BRAKE PERFORMANCE	5. TYPE OF REPORT & PERIOD COVERED: Final
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s): CPT Robert E. Dillon, Jr. Henry T. Nagamatsu (RPI, Troy, NY)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 2080.15.6000.0 PRON No. 1A1221B81A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE: February 1984 13. NUMBER OF PAGES: 79
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Blast Overpressures
Godunov
Method of Characteristics
Perforated Muzzle Brake
Shock Waves
Rarefaction

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Excessive blast overpressures are adversely affecting the safety and performance of artillery crews. A recent trend has been the production of higher blast overpressures necessitated by the need for greater range of these weapons. The need for reduced recoil characteristics of these weapons has led to the use of muzzle brakes to attenuate the recoil momentum. One adverse effect of using a muzzle brake is the shifting of the blast field rearward,

(CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

thus elevating the blast overpressure in the crew area. One possible method of providing a braking force without the high blast overpressure is the perforated muzzle brake. The device is an extension of the gun tube with vent nozzles to discharge the propellant gas radially, hence recovering a finite amount of recoil momentum. The method of characteristics is used to predict the performance of perforated muzzle brakes. The muzzle brake is configured with constant diameter nozzles to vent the propellant gases perpendicular from the axis of fire. An axisymmetric inviscid Godunov finite difference scheme is used to model the external flow field produced by the perforated muzzle brake. Predictions of recoil efficiency of a perforated brake are presented. Comparisons of the flow fields generated by the bare muzzle, a double baffle brake, and a perforated brake are made for a 20 mm gun.

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1. REPORT NUMBER ARLCB -TR-84003	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF MANGANESE PHOSPHATE COATINGS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. A. FARRARA		8. CONTRACT OR GRANT NUMBER(s)
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Manganese Phosphate
Endurion Phosphate
Corrosion Resistance
Wear Resistance

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The corrosion and wear resistance of two different manganese phosphate coatings with supplementary coatings of either oil or heat cured solid film lubricant (SFL) were compared. The basic, heavy manganese phosphate was compared to manganese phosphate converted or modified via the "Endurion" process. The corrosion resistance of the Endurion phosphate was significantly superior to the basic manganese phosphate. Endurion phosphate with a supplementary coating of oil did not fail after 600 hours in the 5% salt spray chamber whereas basic

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20. Abstract (cont'd)

manganese phosphate with a supplementary coating of SFL failed after 206 hours (91 - 133 hours with supplementary coatings of oil). However, the wear resistance of Endurion phosphate with supplementary coatings was approximately identical to the basic manganese phosphate with supplementary coatings.

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1. REPORT NUMBER ARLCB-TR-84004	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AN EXPERIMENTAL STUDY OF PERFORATED MUZZLE BRAKES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) CPT Robert E. Dillon, Jr. Henry T. Nagamatsu (RPI, Troy, NY)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No, 2080.15.6000.0 PRON No. 1A1221B81A1A
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18. SUPPLEMENTARY NOTES
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Perforated Muzzle Brake
Muzzle Blast
Shock Wave

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
A firing test was conducted to examine the recoil efficiency and blast characteristics of perforated muzzle brakes fitted to a 20 mm cannon. Recoil impulse blast overpressures, muzzle velocity, sequential spark shadowgraphs, and photographs of the muzzle flash structure were obtained. Three different muzzle devices were used with one device equipped with pressure transducers to measure the static pressure in the brake. Experimental results are compared with the earlier predictions of Dillon and Nagamatsu.

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4. TITLE (and Subtitle) A MATERIAL MODEL FOR REVERSE YIELDING AND ITS APPLICATION TO TORSION		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Peter C. T. Chen		8. CONTRACT OR GRANT NUMBER(s)
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Reverse Yielding
Bauschinger Effect
Torsion Bar
Plastic Deformation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A theoretical model for reverse yielding is proposed with an attempt to give a better representation for some material such as a high strength steel. The Bauschinger effect factor is treated as a function of overstrain. The strain-hardening effect is taken into account with different parameters used for forward and reversed loading processes. The application of this model to the torsion problem in a cylindrical bar is shown.

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4. TITLE (and Subtitle) OBSERVATIONS ON THE AUS-QUENCHING OF GUN STEEL AND RELATED PROPERTIES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Charles J. Nolan		8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Gun Steel
Hardenability
Aus-Quenching
Microstructure
Mechanical Properties

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A reforged tube section was aus-quenched and tempered. Tensile and Charpy V-notch properties were determined at three locations in the forging, as well as the parent tube. No significant differences were observed in the strength, ductility, or toughness of the aus-quenched forging as compared to the conventionally heat-treated parent tube. It was further determined that a tempered martensitic microstructure was obtained in all sections for both methods of heat treatment.

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10. PROGRAM ELEMENT, PROJECT, TASK
AREA & WORK UNIT NUMBERS

AMCMS Nos. 5025.13.84200.01 and 502E.11.29400

DA Project Nos. 1C024401A110 and 1T062105A328

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-84007	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): THERMAL AND TRANSFORMATION STRESSES IN HOLLOW TUBES DURING THE QUENCHING PROCESS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): J. D. Vasilakis	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, DRSMC-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6111.02.H600.011, PRON No. 1A325B541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: March 1984
	13. NUMBER OF PAGES: 44
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at First Army Conference on Applied Mathematics and Computing, George Washington University, Washington, D.C., 9-11 May 1983. Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Quenching Process
Thermal Stresses
Transformation Stresses
ADINA Finite Element Code
Hollow Tubes

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

During the heat treatment of components, the transient thermal stresses can be very high. This is especially true if a severe quench is required such as the quenching of steel gun tubes for the development of a martensitic grain structure. In addition to the large transient thermal stresses, severe transformation stresses also exist due to the structural volume change involved. If these stresses are high enough, inelastic response of the material must be

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20. ABSTRACT (CONT'D)

considered and residual stresses will exist in the structure when the process is complete. In this report, both thermal and transformation stresses are computed for various quenching procedures using a hollow tube for the geometric model. The relative severity of the thermal and transformation stresses and the conditions under which they occur are discussed. A general purpose finite element code, ADINA, is used for the computation.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84008	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ON THE EXTREMUM OF BILINEAR FUNCTIONAL FOR HYPERBOLIC TYPE PARTIAL DIFFERENTIAL EQUATIONS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. N. Shen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS NO.6111.02.H600. 011 PRON NO. 1A325B541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE April 1984 13. NUMBER OF PAGES 32
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at the First Army Conference on Applied Mathematics & Computing George Washington University,Washington, DC, 9-11 May 1983.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Second Variations
Hyperbolic Type PDE
Finite Element Method
Beam Equation
Bilinear Functional

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Transient solutions of the hyperbolic type partial differential equations are needed for solving many engineering problems such as computing stress waves for gun dynamics or determining shock behaviors of penetration mechanics.

Variational procedures using the bilinear formulations with adjoint variables can serve as the theoretical basis in the derivation of algorithms for the (CONT'D)

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20. ABSTRACT (CONT'D)

finite element methods, giving direct numerical solutions for partial derivatives of the functions to be found for these problems. The adjoint system can be arranged in a manner that it is a reflected mirror of the original system in time. Generalized boundary conditions employ many types of "springs" relating the various spatial partial derivatives. They are defined to satisfy the boundaries of the concomitant for the bilinear expression. Algorithms for use in the finite element method are simplified since the adjoint system gives exactly the same solutions as that of the original system. The second necessary condition for an extremum is satisfied by showing that the second variation is positive semi-definite.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84009	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* J-R CURVE DETERMINATION USING PRECRACKED CHARPY SPECIMENS AND THE LOAD-DROP METHOD FOR CRACK GROWTH MEASUREMENTS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Joseph A. Kapp		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A325B541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE April 1984 13. NUMBER OF PAGES 22
14. MONITORING AGENCY NAME & ADDRESS(*if different from Controlling Office*)		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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18. SUPPLEMENTARY NOTES

Presented at Sixteenth National Symposium on Fracture Mechanics, Columbus, Ohio, 15-18 August 1983.
Published in proceedings of the symposium.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Fracture
Test Methods
J-R Curves
Toughness
Precracked Charpy Specimens

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

J-R curves for two aluminum alloys, a titanium alloy and a high strength-low alloy steel at two different strength levels were determined using precracked Charpy specimens. Three methods were used to measure crack growth: (1) multi-specimen, (2) compliance unloading, and (3) the "load-drop" method. The "load-drop" method assumes that crack growth occurs only after peak load has been attained and the amount which the load decreases after peak load is related to

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20. ABSTRACT (CONT'D)

the size of the uncracked ligament. Comparisons between the three methods for all of the materials show remarkably similar J-R curves. Also, using these curves to determine a J_{Ic} indicates very little difference between the "load-drop" method and the others in the measurement of toughness.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: Contractor Report ARLCB-CR-84010	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): IMPROVED CONVENTIONAL ARMAMENT SYSTEM AUTOLOADER	5. TYPE OF REPORT & PERIOD COVERED: Final, Sep 1983 - Feb 1984
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s): DAAA22-83-C-0196
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Emerson Electric Company, Electronics and Space Division, 8100 W. Florissant, St. Louis, Missouri 63136	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: April 1984
	13. NUMBER OF PAGES: 370
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): US Army Armament Research & Development Center, Benet Weapons Laboratory, DRSMC-LCB-TL, Watervliet, NY 12189	15. SECURITY CLASS. (of this report): UNCLASSIFIED
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Donald E. Jones - Benet Weapons Laboratory Project Engineer

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Autoloader	LAP	Basic Issue Module
120mm Cannon	AFARV	
Separated Ammunition	Brass 2000	
ICAS	Remote Operation	
Ammunition Canister	Pneumatic Ramming	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A conceptual design for a 120mm Improved Conventional Armament System (ICAS) autoloader is presented in this report. This is a multiple mechanism system using microprocessor control. It is designed to load a separated round of ammunition at a rate of 8-12 rounds per minute. The ammunition is packaged in a single canister and transported in a Basic Issue Module. The autoloader is totally remote. Provisions have been made for manual loading under emergency situations.

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20. ABSTRACT (CONT'D)

High reliability goals have been set and human factors engineering has been applied to this design. Program costs and a cost estimate to fabricate a laboratory demonstrator are included.

A data package consisting of Level 1 drawings presents the design in detail and is not included in this report.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Contractor Report ARLCB-CR-84011	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): CONCEPTUAL AUTOLOADER DESIGN STUDY FOR FUTURE ARMAMENT SYSTEM FOR COMBAT VEHICLES (FASCV)	5. TYPE OF REPORT & PERIOD COVERED: Final, Sep 1983 - Feb 1984
	6. PERFORMING ORG. REPORT NUMBER: E-2258
7. AUTHOR(s): B. D. Goodell, M. W. Osborne, R. A. Dahl, R. V. Hettwer, R. C. H. Schmidt	8. CONTRACT OR GRANT NUMBER(s): DAAA22-83-C-0197
9. PERFORMING ORGANIZATION NAME AND ADDRESS: FMC Corporation, Northern Ordnance Division, 4800 East River Road, Minneapolis, MN 55421	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: April 1984
	13. NUMBER OF PAGES: 269
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office): US Army Armament Research & Development Center, Benet Weapons Laboratory, DRSMC-LCB-TL, Watervliet, NY 12189	15. SECURITY CLASS. (of this report): UNCLASSIFIED
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Donald E. Jones - Benet Weapons Laboratory Project Engineer

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Autoloader	AFARV
120mm Cannon	Brass 2000
Separated Ammunition	Chain Rammer
ICAS	Remote Operation
LAP	Containerized Ammunition Package

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A conceptual design for a 120mm Improved Conventional Armament System (ICAS) autoloader is presented in this report. This is a multiple mechanism system using microprocessor control. It is designed to load a separated round of ammunition at a rate of 8-12 rounds per minute. The ammunition is packaged in a single canister and transported in a five-round clip which is integral to the autoloader. The autoloader is totally remote. Provisions have been made for manual loading under emergency situations.

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20. ABSTRACT (CONT'D)

High reliability goals have been set and human factors engineering has been applied to this design. Program costs and a cost estimate to fabricate a laboratory demonstrator are included.

A data package consisting of Level 1 drawings presents the design in detail and is not included in this report.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Contractor Report ARLCB-CR-84012	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): CONCEPTUAL DESIGN FOR 120mm IMPROVED CONVENTIONAL ARMAMENT SYSTEM (ICAS) AUTOLOADER	5. TYPE OF REPORT & PERIOD COVERED: Final, Sep 1983 - Feb 1984
	6. PERFORMING ORG. REPORT NUMBER: FTR-ICAS-01
7. AUTHOR(s): James E. Wildman	8. CONTRACT OR GRANT NUMBER(s): DAAA22-83-C-0198
9. PERFORMING ORGANIZATION NAME AND ADDRESS: ARES, Inc. Bldg. 818, Front St., Erie Industrial Park Port Clinton, Ohio 43452	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE: April 1984
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Donald E. Jones - Benet Weapons Laboratory Project Engineer

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Autoloader	Ammunition Canister	Remote Operation
120mm Cannon	LAP	
Separately Loaded Ammunition	AFARV	
ICAS	Brass 2000	
Palletized Ammunition	Chain Rammer	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The conceptual design of the 120mm Improved Conventional Armament System (ICAS) autoloader is presented in this report. This is a multiple mechanism system using microprocessor control. It is designed to load a separate projectile and powder charge at a rate of 8-12 rounds per minute. The ammunition is packaged in a single canister and transported on 8-10 round pallet which is integral to the autoloader. The autoloader is totally remote. Provisions have been made for manual loading under emergency

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20. ABSTRACT (CONT'D)

situations. The system has an integral auxiliary hydraulic power unit, for silent watch applications or there is vehicle system power failure.

High reliability goals have been set and human factors engineering has been applied to this design. Program costs and a cost estimate to fabricate a laboratory demonstrator are included.

A data package consisting of Level 1 drawings presents the design in detail and is not included in this report.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-MR-84013	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Cadmium Plating vs. Other Coatings to Prevent Corrosion		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. A. FARRARA		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Armament Research and Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, N.Y. 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS NO: 3111.16.2223 D.A.Proj. PRON NO: 1A0204921A1A
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Armament Research and Development Center Large Caliber Weapon Systems Laboratory Dover New Jersey 07801		12. REPORT DATE April 1984 13. NUMBER OF PAGES 8
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Corrosion Protection
Coatings
Hydrogen Embrittlement

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The electrodeposited cadmium coating used to prevent corrosion of screws can cause hydrogen embrittlement type failures. Protective coatings applied to screws by processes other than electrodeposition were tested for corrosion resistance (5% salt spray test). The corrosion resistance of cadmium plated screws was significantly superior to the other coatings selected as possible canidates for replacing cadmium.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-SP-84014	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) The Propellant Combustor Performance Tester		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Alfred R. Graham		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Armament Research and Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, N. Y. 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No.6111.01.91A0.0 PRON NO.1A325D021A1A
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Armament Research and Development Center Large Caliber Weapon Systems Laboratory Dover, New Jersey, 07801		12. REPORT DATE May 1984 13. NUMBER OF PAGES 18
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at the 1984 JANNAF Propulsion meeting, Marriot Hotel, New Orleans, LA, 7-8 Feb. 1984. To be published in the proceedings of the meeting

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Experimental Propellant Performance
Regenerative Liquid Propellant Gun
Fractional Burning Rate
Combustion Liquid Monopropellant
Characteristic Exhaust Velocity
Completeness of Combustion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A newly conceived test device, the Propellant Combustor Performance Tester, has the ability to measure the performance of various liquid monopropellants under steady state conditions at gun pressures; performance is measured in terms of the characteristic exhaust velocity c*. A rocket-like combustion chamber is used, and length may be varied so that flame length, or characteristic length L* may be measured; as well as the fractional burning rate, closely associated with accoustical combustion instability. For a given propellant, the effect of injector configuration may also be studied.

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20. Abstract (cont'd)

This device has been designed and built with successful preliminary shake-down tests complete. The Propellant Combustor Performance Tester (PCTP), once developed, can be applied immediately to evaluate potential liquid propellants for LP gun application, from a combustion standpoint. It can be used directly to solve combustion instability problems in RLPGs.

The Propellant Combustor Performance Tester can become the new standard of the Regenerative Liquid Propellant Gun industry.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84015	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A PARAMETRIC STUDY OF PERFORATED MUZZLE BRAKES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert E. Dillon, Jr.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 2080.15.6000.0 PRON No. 1A1221B81A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE May 1984 13. NUMBER OF PAGES 26
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Perforated Muzzle Blast
Muzzle Blast
Muzzle Flash
Overall Efficiency
Gas Dynamic Efficiency

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A firing test was conducted to study the parameters influencing the recoil efficiency and the blast characteristics of perforated muzzle brakes. Several scaled (20 mm) devices were tested as candidates for the 105 mm Light Assault Vehicle. Recoil impulse, blast overpressures, muzzle velocity, sequential spark shadowgraphs, and photographs of the muzzle flash were obtained. A total of nine different perforated brakes were tested as well as a scaled M198 double muzzle brake.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84016	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LONGITUDINAL VIBRATIONS OF RODS OF FINITE LENGTH WITH RADIAL DEFORMATION		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Julian J. Wu and W. H. Chen (see reverse)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A325B541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE May 1984 13. NUMBER OF PAGES 25
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at Second International Modal Analysis Conference, Orlando, FL, 6-9 February 1984.
Published in proceedings of the conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Vibrations	Radial Deformation
Wave Propagation	Approximate Theory
Rods	Eigenvalue Problems

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An approximate theory of dynamics of rods was formulated by Mindlin and Herrmann in 1951. The unique feature of this theory is that it can model the longitudinal as well as the radial motions of a rod, and yet it can retain the simplicity of a one-dimensional problem in the axial direction. Solutions pertaining to rods of infinite length were also given by Mindlin and Herrmann. This report presents vibration solutions of this rod model with finite lengths. First,
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7. AUTHORS (CONT'D)

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Department of Power Mechanical Engineering
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Hsinchu, Taiwan, Republic of China

20. ABSTRACT (CONT'D)

the set of two partial differential equations is recapitulated together with appropriate boundary conditions. For vibration problems, two sets of eigenvalue problems are formulated to satisfy the simultaneous partial differential equations and the homogeneous boundary conditions. Suitable parameters are defined to describe the dispersion relations. These dual eigenvalue matrix equations are then solved numerically. For an infinite rod, a dispersion relation of frequency versus wave number which contains an imaginary branch has been obtained. The free vibration problem of a fixed-fixed Mindlin-Herrmann rod has been solved. The numerical values of six (6) lowest frequencies, the associated wave numbers and mode shapes are tabulated for three different slenderness ratios.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84017	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EMBRITTLEMENT OF 4340 TYPE STEEL BY LIQUID LEAD AND ANTIMONY AND LEAD-ANTIMONY SOLUTIONS		5. TYPE OF REPORT & PERIOD COVERED FINAL 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) M. H. Kamdar		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No.6111.02.H600.011 PRON NO.1A325B541A1A
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at 1982 Meeting of AIME, St. Louis, MO, 24-28 October 1982 and published in the Proceedings of the Conference.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Liquid Metal Embrittlement
Mechanisms of Embrittlement
Reduction in Cohesion
Grain Boundary Diffusion
Embrittlement of 4340 Type Steel
Embrittlement by Lead, Antimony, and Lead-Antimony Solutions

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study has been made of the fracture behavior of single-edge notched specimens of 4340 type steel tested in cyclic fatigue at temperatures ranging from 675°F to 1350°F in high purity lead and antimony and liquid lead containing 5 to 75 percent antimony in solution. The susceptibility to embrittlement by liquid lead decreases with temperature. The fracture mode changes from intergranular at low temperatures to ductile at 1200°F. In lead solutions, at low

(CONT'D ON REVERSE)

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20. ABSTRACT (CONT'D)

temperatures (700°F) and low concentrations of antimony (5 to 25 percent), embrittlement is caused by liquid lead only. At high temperatures (1000 to 1200°F) and high concentrations of antimony (35 to 75 percent Sb), antimony is the primary embrittling species. Antimony induced embrittlement by lead-antimony solutions occurs by intergranular fracture mode. This variation in susceptibility to embrittlement with temperature indicates that at low temperatures embrittlement is caused by liquid lead and occurs by "reduction in cohesion" mechanism; while at elevated temperatures embrittlement is induced by antimony and occurs by temperature dependent grain boundary diffusion controlled processes. These and other results are also discussed in terms of the current understanding of liquid metal and temper embrittlement of metals.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR- 84018	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* RESIDUAL STRESS MEASUREMENT IN CIRCULAR STEEL CYLINDER		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* J. Frankel, W. Scholz*, G. Capsimalis, and W. Korman (*See reverse)		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No.6940.0R.3570.0 Prom No.1A425N1A1A
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18. SUPPLEMENTARY NOTES

Presented at the IEEE Symposium on Sonics & Ultrasonics, at Atlanta, GA, 31 Oct - 2 Nov 1983. To be published in the Symposium proceedings.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Ultrasonics
Residual Stress

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Hoop residual stresses in a right circular steel cylinder were determined by ultrasonic velocity measurements. The zero stress position was obtained from an equilibrium condition, setting the integrated tensile equal to the integrated compressive hoop stress. Absolute stress values were obtained with the help of calibration measurements on a rectangular test bar of the same material, which was subjected to known applied forces. The stresses determined
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7. AUTHOR(S) (CONT'D)

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20. ABSTRACT (CONT'D)

from these ultrasonic velocity measurements are in good agreement with values obtained by x-ray diffraction analysis of lattice strains.

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1. REPORT NUMBER ARLCB-TR-84019	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* THE BAUSCHINGER AND HARDENING EFFECTS ON RESIDUAL STRESSES IN AN AUTOFRETTAGED THICK-WALLED CYLINDER		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Peter C. T. Chen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A425M541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE June 1984 13. NUMBER OF PAGES 17
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18. SUPPLEMENTARY NOTES

Presented at 1984 Pressure Vessel and Piping Conference, San Antonio, Texas, 17-21 June 1984.
Published in ASME Journal of Pressure Vessel Technology.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Residual Stress	Bauschinger Effect
Autofrettage	Hardening Effect
Gun Tube	Reverse Yielding

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Most of the earlier solutions for residual stresses were based on the assumption of elastic unloading and only a few considered reverse yielding. In this report a new theoretical model for a high strength steel is proposed and a closed-form solution for calculating residual stresses in autofrettaged tubes has been obtained. The new results indicate that the influence of the combined Bauschinger and hardening effects on the residual stress distribution is significant.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84020	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) WALL THICKNESS AND VENT AREA EFFECTS ON PERFORATED MUZZLE BRAKE PERFORMANCE		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) CPT Robert E. Dillon, Jr.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 2080.15.6000.0 PRON No. 1A1221B81A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE June 1984 13. NUMBER OF PAGES 69
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Shock Bottle
Pressure Ratio
Ballistic Efficiency
Gas Dynamic Efficiency

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The firing data of fourteen different perforated muzzle brakes are analyzed in order to describe the parameters of importance to perforated muzzle brake performance. Numerical simulations were made for 20 mm and 105 mm muzzle conditions to study the flow structure in the vent nozzles. Optimum wall thicknesses were identified for various muzzle brake configurations. Blast overpressure levels and recoil efficiencies of all the devices tested are presented.

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1. REPORT NUMBER APLCB-TR-84021	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* STRESS INTENSITY FACTORS FOR A CIRCULAR RING WITH UNIFORM ARRAY OF RADIAL CRACKS OF UNEQUAL DEPTH		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. L. Pu		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS N0.6111.02.H600.011 PRON NO. 1A325B541A1A
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18. SUPPLEMENTARY NOTES

Presented at Second Conference on Applied Mathematics & Computing, RPI, Troy, NY, 22-24 May 1984. To be published in the Proceedings of same conference.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Stress Intensity Factors
Multiple Cracks
Cracks of Unequal Lengths
Fracture Mechanics
Thick-Wall Cylinders

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The plane problem of a uniform array of unequal depth radial cracks originating at the internal boundary of a pressurized circular ring is considered. The 12-node quadrilateral isoparametric elements with collapsed singular elements around crack tips are used to compute stress intensity factors at crack tips.

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20. ABSTRACT (CONT'D)

In a previous study of equal depth radial cracks, the weakest configuration is a ring with two diametrically opposed cracks. The current study shows that if for any reason one of the two cracks should grow a little faster than the other, the stress intensity factor at the tip of the longer crack increases at a much faster rate to enhance the faster growth of the longer crack.

Numerical results are also obtained for cases of three and four radial cracks. It shows the same trend that once one or two cracks grow a little more than the rest, the stress intensity factors at these deeper cracks will be increased progressively higher to keep the faster pace of growth. This explains why the failure caused by a single major crack has been observed most frequently.

A simple linear relation is assumed in this report between the stress intensity ratio and the crack depth ratio. This approximation enables us to estimate stress intensity factors at unequal depth cracks by a method of total differentials. The estimations thus obtained are close to stress intensity factors computed from the finite element.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-84022
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): EMBRITTLEMENT OF GUN STEEL BY COPPER
5. TYPE OF REPORT & PERIOD COVERED: Final
6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): R. M. Fisher, A. Szirmae, and M. H. Kamdar (CONT'D ON REVERSE)
8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, DRSMC-LCB-TL, Watervliet, NY 12189
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18. SUPPLEMENTARY NOTES

Presented at Fall Symposium of AIME, 24-28 October 1982, St. Louis, MO. Published in the Proceedings of Symposium on Liquid and Solid Metal Induced Embrittlement.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Embrittlement
Gun Steel
Copper Rotating Band
Erosion
Liquid Copper
Cracking by Copper
Rotating Bands

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Metallographic examination of the bore surfaces of cannon tubes revealed a close association of copper with the erosion and cracking that occurs during firing. Metallic copper, transferred by abrasive contact between the steel surface and the copper rotating band on the projectile that engages the rifling, can induce embrittlement and enhance propagation of cracks developed by the thermal-mechanical stresses generated during firing. Corroborative experiments (CONT'D ON REVERSE)

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7. AUTHORS (CONT'D)

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Research Laboratory
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20. ABSTRACT (CONT'D)

using capacitance discharge heating verified that copper-induced embrittlement and cracking can occur during a thermal pulse of only a few milliseconds duration. Hot tensile testing with a Gleeble machine confirmed that copper penetrates austenite grain boundaries causing hot tearing in just a few seconds at 1000°C, i.e., well below the melting point of copper.

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-84023	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): A SIMPLE, FRACTURE MECHANICS BASED METHOD FOR FATIGUE LIFE PREDICTION IN THICK-WALLED CYLINDERS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): David P. Kendall	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, DRSMC-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: None
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: July 1984
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18. SUPPLEMENTARY NOTES

Presented at ASME Pressure Vessel & Piping Conference, San Antonio, Texas, 18-21 June 1984.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Pressure Vessels
Fatigue Fracture Mechanics
Bauschinger Effect
Residual Stress

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A method is proposed for predicting the fatigue life of thick-walled cylinders based on numerical integration of the fatigue crack growth curve as determined from a fracture mechanics analysis. The effects of autofrettage residual stresses, crack shape, and of the compressive portion of the stress intensity factor are accounted for. A method for correcting the autofrettage residual stresses for the Bauschinger Effect, based on recent analytical results by

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20. ABSTRACT (CONT'D)

Peter Chen, is also included. A simple computer program for performing the calculation of fatigue life is presented along with a comparison of the calculated results with the experimental results of Davidson, and of Throop and Fujczak.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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4. TITLE *(and Subtitle)* INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1983		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* R. D. Neifeld		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Benet Weapons Laboratory
Technical Publications
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Abstracts
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This is a compilation of Benet Weapons Laboratory technical reports published during 1983.

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1. REPORT NUMBER ARLCB-TR-84025	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* WIDE RANGE DISPLACEMENT EXPRESSIONS FOR STANDARD FRACTURE MECHANICS SPECIMENS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. A. Kapp, G. S. Leger, and Bernard Gross (CONT'D ON REVERSE)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A325B541A1A
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18. SUPPLEMENTARY NOTES

Presented at Sixteenth National Symposium on Fracture Mechanics, Columbus, Ohio, 15-18 August 1983.
Published in proceedings of the symposium.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Fracture Mechanics
Testing Methods
Specimen Characterization

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Wide range algebraic expressions for the displacement of cracked fracture mechanics specimens are developed. For each specimen two equations are given: one for the displacement as a function of crack length and the other for crack length as a function of displacement. All of the specimens that appear in ASTM Standard E-399 are represented in addition to the crack mouth displacement for a pure bending specimen. For the compact tension sample and the disk-shaped
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7. AUTHORS (CONT'D)

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20. ABSTRACT (CONT'D)

compact tension sample, the displacement at the crack mouth and at the load line are both considered. Only the crack mouth displacements for the arc-shaped tension samples are presented. The agreement between the displacements or crack lengths predicted by the various equations and the corresponding numerical data from which they were developed are nominally about three percent or better. These expressions should be useful in all types of fracture testing including J_{Ic}, K_R, and fatigue crack growth.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84026	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* HYDROSTATIC EXTRUSION AND MECHANICAL PROPERTIES OF TUNGSTEN ALLOY PENETRATORS		5. TYPE OF REPORT & PERIOD COVERED FINAL 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Charles J. Nolan and M. H. Kamdar		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, DRSMC-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No.6446.01.0310.0 PRON No.1A425V641A1A
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Warm Hydrostatic Extrusion	Tensile Strength
Liquid Phase Sintered Tungsten Alloy	Fracture Toughness
High Pressure	Fracture Mode

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

An investigation was conducted to determine the effect of large deformations on the mechanical properties and fracture mode of liquid phase sintered 90W-7Ni-3Fe alloy. The alloy was hydrostatically extruded to 20, 50, and 65 percent reduction-in-area at 500°F. The strengthening of the alloy occurred by plastic deformation of both the matrix phase and the tungsten grains. The yield and the ultimate tensile strengths in excess of 200 Ksi were obtained by warm extruding

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20. ABSTRACT (CONT'D)

50 and 65 percent with adequate ductility and fracture toughness. A transition in the fracture mode from interparticle separation to transcrystalline cleavage was observed for the extruded material. The ballistic performance of the extruded alloy was significantly superior to that of swaged material and this appears to be related to the change in the fracture mode.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84027	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Computer Aided Process Planning of Machined Metal Parts		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Captain Walter W. Olson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Armament Research & Dev Center, HQ, U.S. Army, Armament, Munitions and Chemical Command, Benet Weapons Laboratory, Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3297.06.7724 DA Project M1-1-P2613-M1-1A PRON No. 68V7724
11. CONTROLLING OFFICE NAME AND ADDRESS Armament Research & Dev Center, HQ, US Army, Armament, Munitions and Chemical Command, Dover, NJ 07801		12. REPORT DATE September 1984 13. NUMBER OF PAGES 26
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer Aided Process Planning
Variance Systems
Generative Systems
Functional Analysis
Expert Systems
Machineability

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Although process planning is more of an art than a science today, its automation is both possible and feasible. Variant computer aided systems exist and can be applied now. These systems should not have a great effect upon organizational structure. Generalized generative process planning does not exist and probably will not in the near future. However, several special purpose generative systems are available in experimental form. The capabilities of these systems must be planned during the design by a judicious choice of approaches and properties to solve the process planning problem.

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20. Currently, generative systems should be designed for a specific plant or for specific processes. A generative system, if employed, must be considered in the overall scope of computer integrated manufacturing as it needs data existing in other data bases and it has potential organizational impact.

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84028	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* SECONDARY WAVES FROM NOZZLE BLAST		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Garry C. Carofano		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A425M541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE October 1984 13. NUMBER OF PAGES 40
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16. DISTRIBUTION STATEMENT *(of this Report)*

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18. SUPPLEMENTARY NOTES

Presented at the Technical Coordinating Panel Workshop on Weapon Launch Blast Overpressure, RARDE, Ft. Halstead, Kent, England, 26-29 July 1983. Published in proceedings of the workshop.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Impulse Noise	Recoilless Rifles
Blast	Blast Computation
Rocket Launcher	Secondary Waves

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Blast signatures at the gunner's position produced by recoilless rifles and rocket launchers often exhibit a strong secondary wave following chamber blowdown. To identify its source, a series of experiments was performed using a helium-driven blast simulator. The resulting pressure traces and shadowgraphs show the wave emerging from the portion of the plume just aft of the nozzle, but leave unexplained its relationship to the plume flow field structure. This information was obtained from a numerical solution of the Euler equations using
(CONT'D ON REVERSE)

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20. ABSTRACT (CONT'D)

Harten's Total Variation Diminishing (TVD) scheme. Based on this data, contour and surface plots of pressure were constructed which reveal quite clearly the plume wave structure and its response to the falling chamber pressure. A secondary wave emerges from the same region of the plume as it did in the experiment.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84029	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) BLAST COMPUTATION USING HARTEN'S TOTAL VARIATION DIMINISHING SCHEME		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Garry C. Carofano		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A425M541A1A
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Blast Computation
Numerical Methods

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A model for blast flow field calculations involving two distinct gases is described. It is based upon the Euler equations and Harten's Total Variation Diminishing (TVD) scheme is used as the equation solver. The eigenvalues and eigenvectors are first derived for a general equation of state. Then a particular equation of state is presented for a mixture of two ideal gases. The model predictions show good agreement with experimental data for a shock diffraction around a corner.

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1. REPORT NUMBER ARLCB-TR-84030	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* ELECTRICAL RESISTIVITY IN LOW RESISTIVITY AMORPHOUS ALLOYS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) L. V. Meisel and P. J. Cote		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No.6111.02.H600.011 Pron No.1A325B541A1A
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18. SUPPLEMENTARY NOTES

Presented at the Fifth International Conference on Liquid & Amorphous Metals, Los Angeles, California, 15-19 August 1983

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Amorphous Alloys
Electron Transport
Diffraction Model
Saturation

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The temperature dependence of the electrical resistivity in low resistivity ($\rho < 100\ \mu\Omega$cm) amorphous alloys is analyzed in the framework of the diffraction model. The standard diffraction model yields results in qualitative agreement with the available data. However, a quantitative agreement with the data is observed if phonon ineffectiveness effects are included by means of the Pippard-Ziman constraint. A variety of results are presented for ranges of $2k_F/k_p$ and electron mean free paths.

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1. REPORT NUMBER ARLCB-TR-84031	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) APPLICATION OF THE DIFFRACTION MODEL TO AMORPHOUS MAGNESIUM ZINC ALLOYS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. J. Cote and L. V. Meisel		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No.6111.02.H600.011 Pron No. 1A325B541A1A
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Amorphous Alloys
Electron Transport
Diffraction Model
Saturation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Amorphous magnesium-zinc (a-MgZn) alloys comprise the best system available for testing the diffraction model for electron transport in non-crystalline alloys. They are simple metal binary alloys. Conventional methods exist for determining electronic parameters in the model. They exhibit low resistivities so that saturation effects are not expected to dominate. They are well characterized and extensive resistivity data are available.

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20. ABSTRACT (CONT'D)

Computed results presented here are based on a refinement of previous calculations; the alloy scattering matrix elements with computed phase shifts for Mg and Zn are used with the substitutional model instead of the adjusted effective potential assumed previously. Results obtained ignoring mean free path effects are in qualitative agreement with the data; agreement is surprisingly detailed when account is taken of saturation effects.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84032	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* EFFECT OF INTERCONNECTION OF THE ENDS OF A SLIDING BEARING ON FILM THICKNESS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. S. Montgomery		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS NO.6111.02.H600.011 PRON NO. 1A325B541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE September, 1984 13. NUMBER OF PAGES 18
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18. SUPPLEMENTARY NOTES

To be presented at the 1984 ASME-ASLE LUBRICATION CONFERENCE, San Diego, CA October 22-24 1984

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Recoil Mechanisms
Sliding Bearings
Tank Guns

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The effect of the area of interconnection between the ends of fast-acting bearings such as those of recoil mechanisms used with American tank guns was studied with an apparatus which simulated a concentric recoil system. It was found that these bearings do not "starve" with a small interconnection area, but a larger area would probably produce a faster-acting bearing. It would also result in a thinner fluid film but this would probably be unimportant.

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20. ABSTRACT (CONT'D)

The film thickness continues to increase for a time even after the movement of the recoiling tube has stopped, so there appears little chance that the film would entirely collapse before counter-recoil begins. There are two area ratios that result in thinner film thicknesses and slower formation of the fluid film. These area ratios should be avoided. Their locations were at 1.5 and 4.9 mm^2/cm but they might be at different locations with the larger actual recoil bearings and with the geometries of specific designs.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84033	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AUTONOMOUS NAVIGATION FOR MOBILE ROBOT VEHICLES OVER HILLY TERRAIN USING RANGEFINDING MEASUREMENTS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. N. Shen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS NO. 6111.02.H600.011 PRON NO. 1A325B541A1A
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18. SUPPLEMENTARY NOTES Presented at the Robotic Lntelligence & Productivity Conference, Wayne State University, Detroit Michigan, 18-19 Nov. 1983.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Mobile Robot
Vehicle Navigation
Obstacle Detection
Slope Estimation
Path Selection

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The mobile robot vehicle is equipped with data acquisition and decision making devices for its autonomous navigation over rough terrain. A laser rangefinder is chosen as principal sensing device, which can determine radial distances from the vehicle to points on unpredictable hilly terrain surfaces. The overall procedure conducted for such a design consists of the following interrelated subsystems such as scanning scheme, obstacle detection scheme, terrain slope estimation, and path selection algorithm. Stochastic processes and methods are employed throughout the analysis.

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1. REPORT NUMBER: Contractor Report ARLCB-CR-84034	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: STRESS CORROSION CRACKING BEHAVIOR OF TUNGSTEN HEAVY ALLOYS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Jin-Gon Chung David J. Duquette	8. CONTRACT OR GRANT NUMBER(s): DAAA22-81-C-0138
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Materials Engineering Department Rensselaer Polytechnic Institute Troy, NY 12180	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801-5001	12. REPORT DATE: October 1984 13. NUMBER OF PAGES: 147
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18. SUPPLEMENTARY NOTES

Dr. Joseph A. Kapp - Benet Weapons Laboratory, Project Engineer

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

High Density Alloys
Stress Corrosion Cracking
Fracture
Fracture Mechanics
Fracture Mechanisms

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Stress corrosion cracking behavior of 90W-Ni-Fe (W-10) and 97W-Ni-Fe-Cu-Co (W-3) alloys has been studied in solutions of NaCl, NACE, and 10% H_2SO_4. The influences of electrochemical polarization, hydrogen catalyst, and heat treatment on K_{ISCC}, static load crack growth rate, and fracture morphology were studied.

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20. ABSTRACT (CONT'D)

The W-10 alloy exhibited SCC susceptibility in NaCl solution. Electrochemical polarization, addition of a hydrogen catalyst (As) to the NaCl solution and heat treatment in hydrogen increased SCC susceptibility. SCC susceptibility was also observed in the sulfide cracking solution and when cathodically charged in 10% H_2SO_4 with a hydrogen catalyst (As). At the corrosion potential and anodic potentials in NaCl solution, SCC propagated by separation of tungsten-tungsten and tungsten-matrix interfaces with ductile rupture of the matrix. In other cases, cracks propagated by separation of tungsten-matrix and tungsten-tungsten interfaces with some cleavage of tungsten grains.

The W-3 alloy did not exhibit SCC susceptibility in NaCl solution, under any conditions. SCC did occur in the sulfide cracking solution and when cathodically charged in 10% H_2SO_4 with a hydrogen catalyst (As), however, it was much more resistant than the W-10 alloy. Fracture occurred primarily by dimple formation in the matrix and cleavage of tungsten grains.

SCC in the W-10 alloy is thought to occur by electrochemical dissolution of the matrix. Small matrix volume and high tungsten contiguity in the W-3 alloy prevents cracks from growing even though severe matrix dissolution occurs.

The observed susceptibility of both alloys to cracking in the NACE recommended sulfide cracking solution and when cathodically charged in 10% H_2SO_4 with As indicates that both alloys are highly susceptible to hydrogen embrittlement.

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1. REPORT NUMBER ARLCB-MR-84035	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* COMPLIANCE OF A THREE-POINT BEND SPECIMEN AT LOAD LINE		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* Fahmy M. Haggag (EG&G Idaho, Inc., Idaho Falls, ID) and J. H. Underwood		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6910.0R.8990.0 PRON No. 1A425Y421A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE October 1984 13. NUMBER OF PAGES 6
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18. SUPPLEMENTARY NOTES

Submitted for publication in International Journal of Fracture.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Bend Specimen
Compliance
Stress Intensity
Fracture Mechanics

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Load-line displacement information for the three-point bend specimen is presented and compared with information from the literature, with emphasis on the needs of those performing fracture tests.

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1. REPORT NUMBER: ARLCB-TR-84036	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): SECOND VARIATIONS FOR THE STRESS WAVE PROBLEM USING THE EULER-LAGRANGE AND ADJOINT FORMULATIONS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): C. N. Shen	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, SMCAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6111.02.H600.011, PRON No. 1A325B541A1A
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18. SUPPLEMENTARY NOTES

Submitted to Journal of Sound and Vibration.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Second Variations
Adjoint Systems
Hyperbolic P.D.E.
Finite Element
Bilinear Expression

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The adjoint system can be arranged in a manner so it is a reflected mirror of the original system in time. Generalized boundary conditions employ many types of "springs" relating the various spatial partial derivatives. They are defined to satisfy the boundaries of the original and adjoint system relationship for the bilinear expression. Algorithms for use in the finite element method are simplified since the adjoint system gives exactly the same solutions

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20. ABSTRACT (CONT'D)

as those of the original system. The second necessary condition for an extremum is satisfied by showing that the second variation of the functional is positive semi-definite.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-84037	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) STRESS CONCENTRATION DUE TO AXIAL TENSION OF LOADED NONSYMMETRIC-SHAPED GROOVES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Y. F. Cheng		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A425M541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE November 1984 13. NUMBER OF PAGES 26
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18. SUPPLEMENTARY NOTES

Presented at Fifth International Congress on Experimental Mechanics, Montreal, Canada, 10-15 June 1984.
Published in proceedings of the congress.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Lug and Groove Connection
Stress Concentration
Nonsymmetric-Shaped Grooves
Two-Dimensional Photoelasticity
Heywood's Equation

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Lug and groove connections are frequently found in structures where two components meet and loads are transmitted. These grooves usually have a non-symmetric shape, i.e., the flank angle at the loaded face is different from that at the free face. While numerous data on stress concentrations for symmetric-shaped grooves (for example, U- or V-shaped) are available, very little information exists for nonsymmetric-shaped grooves. This report
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20. ABSTRACT (CONT'D)

describes a photoelastic study on stress concentration in plates due to axial tension of loaded nonsymmetric-shaped grooves. Groove geometries as well as loading conditions are given. Maximum groove stresses were found and stress concentration factors were calculated. Also, parametric curves of stress concentration were obtained. A comparison was made between experimental results and those calculated by means of Heywood's equation.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-84038	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: STUDIES OF HYDROSTATIC COEXTRUSION OF DEPLETED URANIUM-0.75 TITANIUM ALLOY REINFORCED WITH TUNGSTEN FILAMENT (A PROGRESS REPORT)	5. TYPE OF REPORT & PERIOD COVERED: Progress Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): I. Ahmad, R. J. Fiorentino, E. G. Smith, Jr., and J. Barranco (see reverse)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, SMCAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6111.02.H600.011, PRON No. 1A325B541A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: November 1984
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Uranium	Interface
Tungsten	Ballistic Tests
Composites	DU-0.75 Ti
Hydrostatic Extrusion	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Composites of depleted uranium-0.75 titanium matrix alloy reinforced with nominally 0.5 V_f tungsten filaments have been fabricated by hydrostatic coextrusion. In the first stage, extrusion reduction ratio of 6:1 at 500-600°C was easily achieved. However, for further reduction, the ratio and temperature of extrusion of 4:1 and 400°C, respectively, were found to be optimum. At higher temperatures and reduction ratios, periodic necking and fracture of filaments occurred. To achieve the final reduction ratio of 48:1, the 24:1

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7. AUTHOR(S) (CONT'D)

R. J. Fiorentino and E. G. Smith, Jr.
Battelle Memorial Institute
Columbus, OH

20. ABSTRACT (CONT'D)

stock obtained in the two-stage extrusion was successfully swaged at 400°C using multipasses. Attempts to eliminate the second extrusion step by following the first-stage extrusion at a 6:1 reduction with a final reduction by hot swaging at 400°C, were partially successful. The tungsten phase was uniformly reduced to 0.050 inch diameter filaments. However, the cross-section of the outer filament did not remain circular at 43:1 reduction rates. Also, cracks developed at the filament-matrix interface and within the filament. Mechanical tests showed that the composite had elastic modulus approaching rule of mixture values. However, the tensile and flexure strengths were lower than the matrix alloy. The matrix alloy specimen produced by two-stage hydrostatic extrusion of cast alloy had tensile properties as good as the conventonal heat treated alloy. In ballistic tests against medium heavy triple-spaced target, the matrix hydrostatically extruded alloy performed as well as the conventional alloy. Also, the composite specimens in spite of the longitudinal cracks, showed complete penetration at 1252 meters/sec striking velocity.

Preliminary ballistics tests showed that hydrostatically extruded (2:1) W-10 alloy outperformed swaged W-10 alloy.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-84039	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: FATIGUE EFFECTS OF M4A2 ZONE 7 ROUND ON 155 MM M185 HOWITZER TUBE LIFE	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Bruce B. Brown	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, SMCAR-LCB-TL, Watervliet, NY 12189-5000	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 2080.15.6000.00, PRON No. 1A1221B81A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Center, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801-5001	12. REPORT DATE: December 1984
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Fatigue
Cannon
Howitzer
Gun Tube
EFC

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The fatigue life of the 155 mm M185 howitzer tube has previously been established for the maximum pressure round, the M119A1 Zone 8. This test program addresses the effects of the next lower pressure standard round - the M4A2 Zone 7. The objective of the program is to determine a recommended Equivalent Full Charge (EFC) factor to be used in accounting for fatigue cyclic increments counted towards the safe service life limit when using a less than full pressure round.

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20. ABSTRACT (CONT'D)

This tube suffers fatigue failure from exterior initiating cracks caused by combined tensile residual stress and the tensile stress of firing pressure. Since the pressure difference of the two rounds is slight and is added to the constant residual stress, the percentage change is small and results in a negligible change in fatigue effect. The EFC factor for the M4A2 Zone 7 round is recommended as 1.0, the same as the M119A1 Zone 8 round.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-84040	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: TEKEDIT - AN ENHANCED EDITOR FOR DIRECT VIEW STORAGE TUBE (DVST) GRAPHICS DISPLAY DEVICES	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Mark Johnson	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, SMCAR-LCB-TL, Watervliet, NY 12189-5000	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Computer Graphics	DVST
Editor	Graphics
Plot 10	Storage Tube

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

An overview and functional description of an editor for host files using Direct View Storage Tubes (DVST) with enhanced refresh capabilities is given. Tekedit is an editor designed to augment a system editor for creating or modifying host files using a graphics terminal as the display device. The initial implementation of Tekedit is for a Tektronix 4114 on an IBM 4341 running VM/CMS.

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4. TITLE (and Subtitle) CHARACTERIZATION OF BORE SURFACE LAYERS IN GUN BARRELS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) M. H. Kamdar and J. D. Venables (SEE REVERSE)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189-5000		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6910.00.H840.021 PRON No. 1A425Q781A1A
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

White Layers
Erosion
Gun Barrels

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Specimens containing white layers were taken from the bore surface of the unplated and chrome plated fired gun tubes. These were examined metallographically and the presence of various "white layers" was established. The chemical and structural nature of these layers was determined by Auger/ESCA and x-ray diffraction techniques. The outermost white layer contained up to seven percent carbon and was identified as cementite - Fe_3C. The subsequent white layers had approximately one percent carbon and were identified as high carbon
(CONT'D ON REVERSE)

7. AUTHOR(S) (CONT'D)

J. D. Venables
Martin Marietta Research Laboratory
Baltimore, MD

20. ABSTRACT (CONT'D)

austenite. The significance of these results is discussed in terms of solution and diffusion of carbon from burnt propellant gases into iron during firing. The carbonaceous gases from the burnt propellant are responsible for the formation of white layers and are the cause of erosion and cracking in the bore surface. During heating and cooling of fired gun barrels, stresses are generated by the differences in the coefficient of expansion and volume changes associated with cementite, austenite, and matrix metal phases. Cracks are produced in the white layer and are propagated in the substrate steel matrix. The high carbon-containing phases are lower melting than steel. These molten phases are eroded away by the sweeping hot propellant gases, thereby eroding the bore surface of the gun barrel. These and other results are discussed in terms of their effects on erosion and wear in the gun barrel bore surfaces.

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4. TITLE (and Subtitle) THE DEVELOPMENT OF A LARGE COMPOSITE ANODE FOR PLATING GUN TUBES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. D'Andrea and R. Murray		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-LCB-TL Watervliet, NY 12189-5000		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3297.06.8152 PRON No. 1A1241721A1A
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Composites
Anode
Plating
High Modulus Graphite/Epoxy

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
A design and a manufacturing process are presented for a twenty-foot long anode to be used in the chrome plating of large caliber gun tubes. This anode provides ease in handling because of lighter weight yet maintains excellent stiffness properties. Considerable cost savings are anticipated by elimination of rework of gun tubes.

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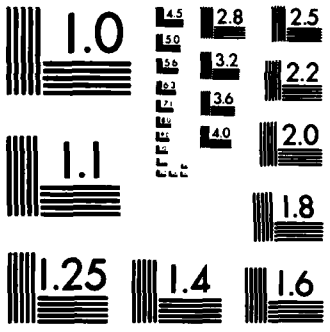

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